

REMARKS

Reconsideration of the application is respectfully requested for the following reasons:

1. Amendments to Specification, Abstract, Drawings, and Claims

The specification and abstract have been amended to place the application in proper U.S. format and correct various minor grammatical and idiomatic errors.

Figs. 1-4 have been amended by correcting the output voltage designator VREF to read -VREF1- (Fig. 1), -VREF2- (Fig. 2), and -VREF3- (Figs. 3 and 4) for consistency with the references thereto in the original specification.

The claims have been amended to correct minor formal errors, to recite first and second voltage level shifting resistances (R3 and R4 illustrated in Figs. 3 and 4), and by combining claims 1-5 to clarify the unique features of the invention, namely the *combination*, in a bandgap reference circuit having transistors and bipolar junction transistors connected in the claimed manner, of:

- (i) the voltage level shifting resistances, and
- (ii) an operational amplifier with an N-type input differential pair.

Because each of the amendments to the specification, abstract, drawings, and claims is formal in nature, it is respectfully submitted that they do not involve "new matter." Entry and consideration of the amendments is accordingly requested.

2. Rejection of Claims 1, 4-7, and 10 Under 35 USC §102(b) in view of U.S. Patent No. 6,362,612 (Harris)

This rejection has been rendered moot by the amendment of claim 1 to include the limitations of original claims 2 and 3, directed to the including of an N-type differential transistor pair in the operational amplifier.

3. Rejection of Claims 1, 4-7, and 10 Under 35 USC §102(b) in view of U.S. Patent Nos. 6,362,612 (Harris) and 6,529,066 (Guenot)

This rejection is respectfully traversed on the ground that neither the Harris patent nor the Guenot patent discloses or suggests, individually or in any reasonable combination, a bandgap reference circuit having transistors and bipolar junction transistors connected in the claimed manner, the bandgap reference circuit further including:

- (i) matching voltage level shifting resistances (R3 and R4 shown in Figs. 3 and 4), and
- (ii) an operational amplifier with an N-type input differential pair.

The Harris patent discloses a circuit that is similar to that of the claimed invention, but difference in the arrangement of the resistances. In particular, Harris does not disclose matching voltage level shifting resistances connected to the inputs of the operational amplifier in the manner claimed. The reason is that Harris is not concerned with small reference voltages, but rather is seeking to increase the change in the base-to-emitter voltage ΔV_{be} across the bipolar transistors setting the **ratio** for the resistances connected to the input ends of the operational amplifier to 0.5 (see col. 6, lines 3-13 of the Harris patent). The reason for seeking to increase ΔV_{be} is to minimize noise for a given resistance value R1.

In contrast, in the circuit illustrated in Figs. 3 and 4 of the present application, nodes N12 and N13 must be equal in order to achieve a meaningful comparison at the inputs to the operational amplifier. This is achieved through the use of resistor R5. In order to maintain this equality, and yet shift the input level of the operational amplifier, the claimed invention uses matching voltage level shifting resistances R3 and R4. The resistances of Harris do not have this function. Instead, they are specifically disclosed as non-matching, with a ratio of 0.5.

It is noted that the Harris patent does claim a 1.3V output voltage. However, unlike the circuit illustrated in Figs. 3 and 4 of the present application, which can be operated to supply a reference voltage of $V_{tn}+3V_{ds,sat}=0.5+3(0.3)=1.4$ (see page 7, lines 3-9 of the original specification), the circuit disclosed in the Harris patent is described as having a minimum voltage path of $V_{gs,M6}+V_{be,Q4}+V_{ds,sat,M4}=0.5V+0.6V+0.2V=1.3V$. Harris thus relies on the base-to-emitter voltage of transistor Q4 and drain-to-source voltage of transistor M4 to achieve the indicated voltages and appears not to have taken into account the effect of the operational amplifier. Without the claimed voltage level shifting resistances, Harris would be forced to use a p-type operational amplifier, resulting in a higher output voltage than suggested by the above formula. In practice, it does not appear possible to achieve a high signal-to-noise ratio, which is the objective of the Harris patent, while using an N type operational amplifier of the type claimed in order to achieve a low reference voltage.

In summary, the Harris patent not only fails to teach the claimed N-type input differential pair, but it fails to disclose a circuit that will support the claimed N-type input differential pair because it does not teach the claimed matching voltage level shifting resistances. This deficiency is not made up for by the Guenot patent, which discloses use of a "boost" voltage applied to the bipolar transistors.

It is true that the Guenot patent teaches, in Fig. 2a, an operational amplifier with an N-type input differential pair. However, the Guenot patent **teaches away** from the claimed voltage level shifting resistances, or the claimed combination of an operational amplifier of Fig. 2a with voltage level shifting resistances. Instead, Guenot teaches an alternative solution to the problem of input voltage levels, namely the application of a "**boost voltage**" to the bases of the bipolar transistors. Therefore, the proposed combination of the Harris and Guenot patents could not have suggested the claimed combination.

According to col. 2, line 61 to col. 3, line 8 of the Guenot patent:

In order for the FIG. 2A amplifier to operate properly, inspection of the input indicates that the voltage at the inputs, the common mode input voltage, must be at least as large as the sum of the gate-source voltage V_{gsn} of N type transistor 16A and voltage V_{dsatn} of tail current source N type transistor. . .

In order to solve this problem, Guenot teaches in col. 3, lines 9-30 that:

One solution to the above noted problem is to use MOSfet having a reduced threshold voltage. . . However, such devices are typically not available on standard CMOS processes. Another approach is to use an input stage having P type devices as shown in Fig. 2B. . .

Thus, Guenot sums up the prior art by stating that the only prior ways to solve the threshold voltage problem associated with an operational amplifier having an N-type differential input pair was to either use fets made by non-standard processes, or to use P type devices.

The solution, described in col. 4, lines 23-33 of the Guenot patent, is to connect a boost voltage to the bipolar junction transistors, rather than to use the “diode” connections of the type disclosed in Fig. 1 of the Guenot patent and in the Harris patent. In other words, Guenot teaches that N type operational amplifiers should not be used in a circuit of the claimed type unless the circuit is further modified by connecting the base electrodes of the bipolar junction transistors to a boost voltage. *In that case, however, it would not be necessary to include voltage level shifting resistances, and the resulting circuit would not correspond to that of the claimed invention.* By teaching that an operational amplifier with an N type differential pair should not be used with a circuit of the type disclosed in the Harris patent, in which the bipolar junction transistors are connected in common with the emitters (i.e., “diode-connected”), the Guenot patent teaches away from the claimed invention.

At the very least, the teachings of the Guenot patent, considered "as a whole" in the manner that the ordinary artisan would have considered them, *i.e.*, without a template to indicate which teaches should be considered and which should be ignored, suggest modifications of the Harris circuit that would have changed the principle of operation of the circuit disclosed therein. As explained in **MPEP 2143.02**, it is not obvious to modify the teachings of a primary reference in a way that changes principles of operation, unless there is a specific teaching to do so:

If the proposed modification or combination of the prior art would change the principle of operation of the prior art invention being modified, then the teachings of the references are not sufficient to render the claims prima facie obvious (citing *In re Ratti*, 270 F.2d 810, 123 USPQ 349 (CCPA 1959)...*The court reversed the rejection holding the "suggested combination of references would require a substantial reconstruction and redesign of the elements shown in [the primary reference] as well as a change in the basic principle under which the [primary reference] construction was designed to operate*" 123 USPQ at 352. (See also, MPEP 2141.02, p. 2100-107 "**A prior art reference must be considered in its entirety, *i.e.*, as a whole, including portions that would lead away from the claimed invention** (emphasis in the original).

It is respectfully submitted that the proposed combination of the operation amplifier illustrated in Fig. 2A of Guenot with the circuit of Harris would have changed the principle of operation of the circuit of Harris, because Guenot teaches that the combination cannot be made without adding a bias voltage to the bipolar junction transistors, and therefore that the proposed combination would not have been obvious to the ordinary artisan. According to Guenot, either a bias must be added to the bipolar transistors, *eliminating the need for the claimed voltage level shifting resistances, or the operational amplifier must have a p-type differential input pair.*

Because the Guenot patent does not teach the claimed modification of the circuit of Harris, but rather teaches away from such a modification, withdrawal of the rejection under 35 USC §103(a) in view of the Harris and Guenot patents is respectfully requested.

Having thus overcome each of the rejections made in the Official Action, withdrawal of the rejections and expedited passage of the application to issue is requested.

Respectfully submitted,
BACON & THOMAS, PLLC



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AMENDMENTS TO DRAWINGS

Please amend Figs. 1-4 by changing "VREF" in each figure to, respectively, VREF1, VREF2, and VREF3, as indicated in the attached REPLACEMENT SHEETS and ANNOTATED SHEETS SHOWING THE CHANGES.

ANNOTATED SHEET SHOWING CHANGES

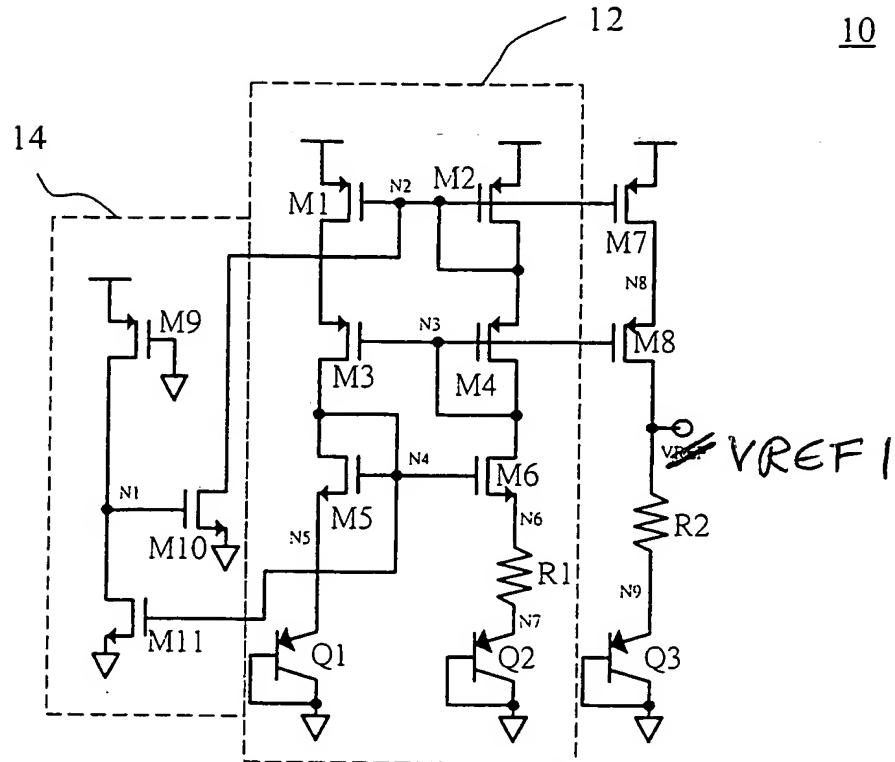


Fig 1 (Prior art)

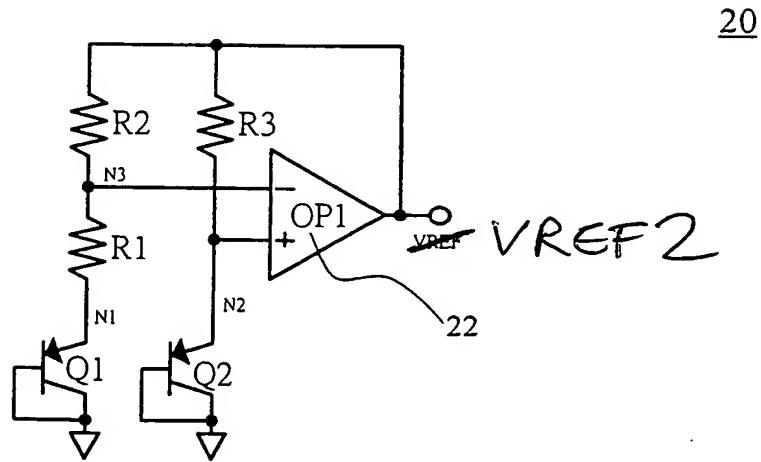


Fig 2 (Prior art)

ANNOTATED SHEET SHOWING CHANGES

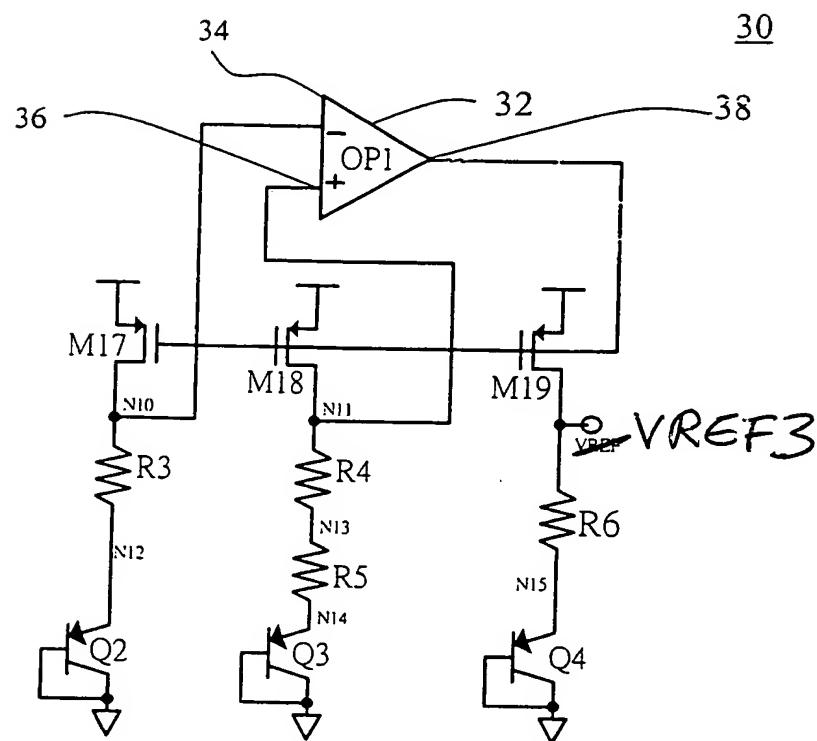


Fig 3.

ANNOTATED SHEET SHOWING CHANGES

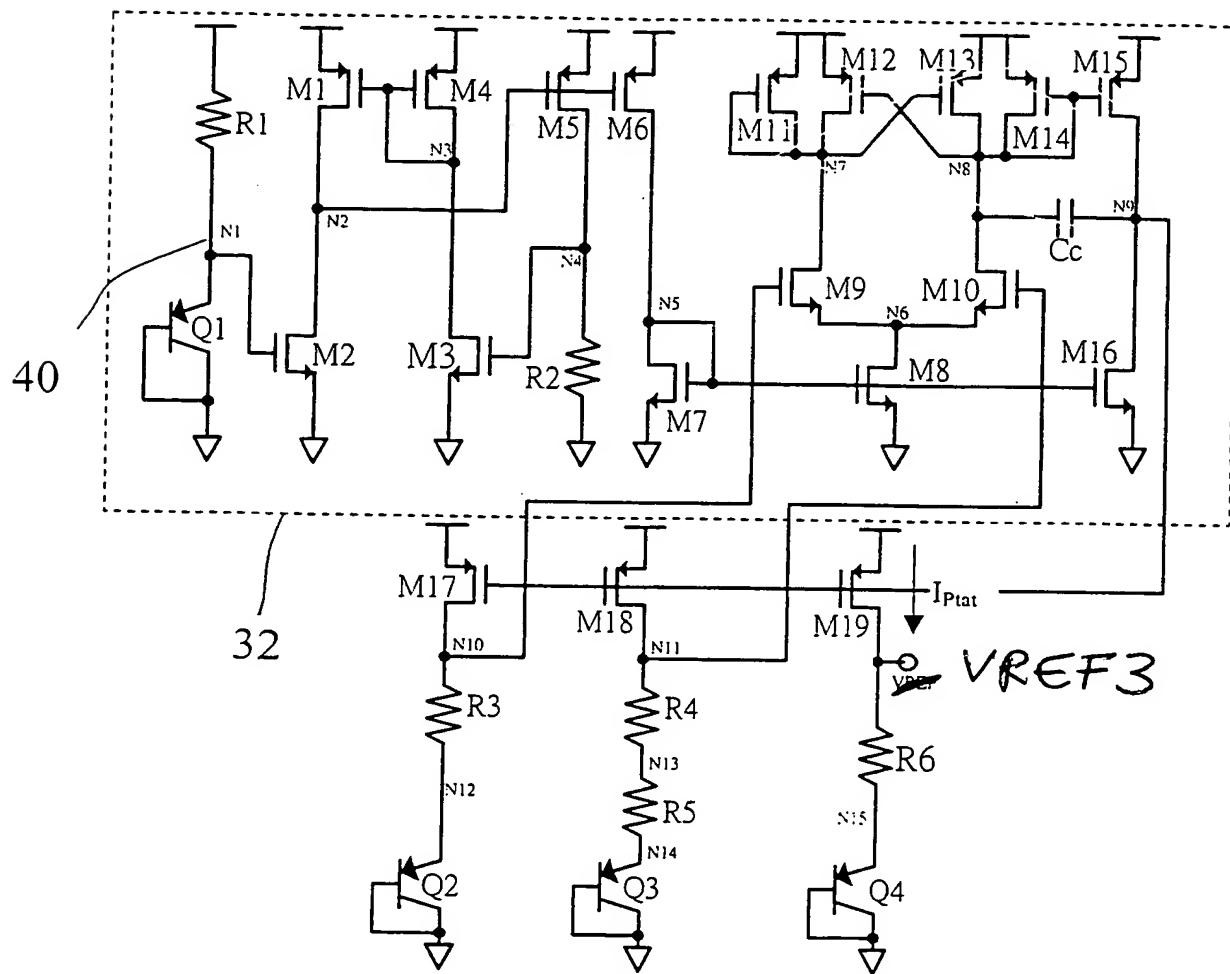


Fig 4.

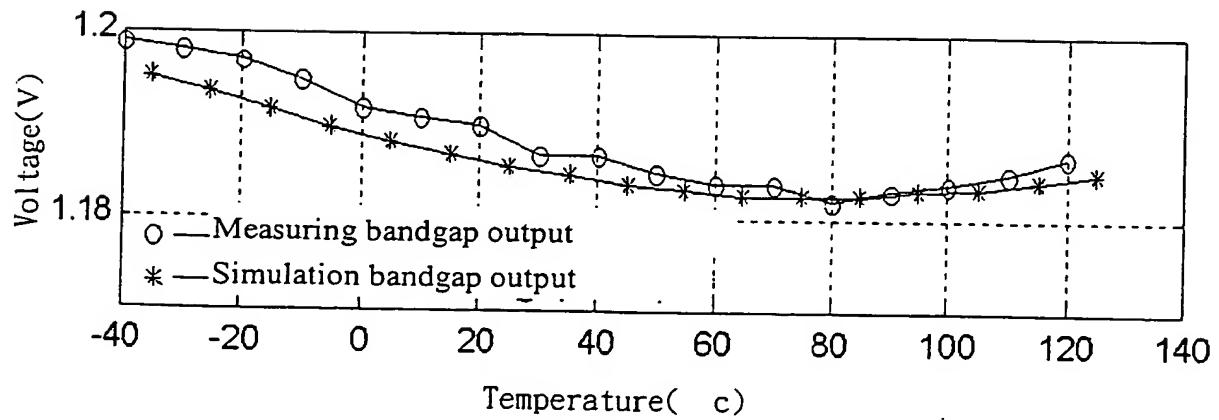


Fig 5.